# A Regional Modeling Study of the South China Sea with High Resolution Hydrostatic and Nonhydrostatic Nested Models of the Luzon Strait

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## LONG-TERM GOALS

The goal of this work is to better understand the generation, propagation, modal transformations and interaction of multiple NLIWs (Nonlinear Internal Waves) on the continental slope and shelf using nonhydrostatic models embedded in nested hydrostatic models with *realistic forcing* and *bathymetry*. Accuracy will be assessed by hindcasting and forecasting the temperature, salinity and velocity fields for the SCS (South China Sea) north and east of Dongsha island and comparing the results with data from the experiments of this DRI and from the ASIAEX experiment.

This work will provide the understanding needed to build an operational system to predict the timing, location and intensity of NLIWs as required for tactical planning.

## OBJECTIVES

- To identify the mechanisms responsible for the generation, propagation, fission, interaction and modal transformations of NLIWs on the slope and the plateau north and east of Dongsha Island in the SCS

- To hindcast these NLIWs using high resolution nonhydrostatic and hydrostatic numerical models with realistic ocean topography and surface forcing and using open boundary conditions provided by the large scale ocean model.

- To determine the space and time scales involved in these processes that influence NLIWs on the continental shelf and slope of the SCS and their relationship to local and remote forcing.

## APPROACH

We have used the nonhydrostatic (NRL-MIT) modeling system embedded in a system of multiply nested hydrostatic Navy Coastal Ocean Model (NCOM) models. The NRL-MIT system consist of the nonhydrostatic version of the MITgcm model wrapped in a suite of scripts that provide initial fields and open boundary values from the NCOM model and handle restart and output in a series of segmented, parallelized integrations that maximize cpu usage and the ratio of system to wall clock time. The forcing consists of surface fluxes from the Coupled Ocean Atmosphere Prediction System (COAMPS) and the Navy Operational Global Atmospheric prediction System (NOGAPS) operational nowcast/forecast system and open boundary conditions from the global NCOM forecasts. The basic bathymetry is the NRL DBDB2 (2 minute) bathymetry which has been enhanced and improved with

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several additional bathymetry databases provided by our Taiwanese collaborators. The hindcasts are done at increasing resolution using additional nested domains.

**WORK COMPLETED**

This fiscal year we have conducted three dimensional hindcasts of a domain (20.5N to 21.5N, 116.5E to 118.5E) north and east of Dongsha Island (Figure 1) at a variety of resolutions from relatively coarse (2km) to moderately high (500m) resolution. These 3D hindcasts of the Dongsha plateau region were forced at the open boundaries with data from Dong Shan Ko's LZS64NFS hindcasts for April 1 to May 1, 2005. LZS64NFS obtains open boundary conditions from Shelley Riedlinger's East Asian Seas 1/16th degree Nowcast/Forecast system (EAS16NFS). Although the timing of the arrival of the tidal-period, trans-basin IWs is in good agreement with observations, the amplitudes of the waves are too small by a factor of roughly 4 (Dong Shan Ko, personal communication) due to the resolution of the model. Furthermore the structure of the waves with respect to the higher frequency NLIWs (solitary waves and wave packets) is not correct because of the hydrostatic assumption which is employed in the NCOM model.

**RESULTS**

The 2°x1° hindcasts discussed here are from the 500 m resolution cases. The timestep was 15 seconds and the simulations used 96 processors on the IBM Power 4+ Cluster at the Navy Oceanographic Office (NAVO) Major Shared Resource Center (MSRC). The results are saved every hour which resolves the semidiurnal tides. At 500m resolution the high frequency NLIWs are not well resolved; however, the large amplitude internal tides are resolved.

The internal waves at the eastern boundary from the LZS64NFS amplify quickly and interact with each other, locally generated waves and the topography. The result is a complex field of large amplitude NLIWs with amplitudes of 100 m and more (Figure 2). The waves propagate roughly east to west; however, refraction caused by interaction with topography and wave-wave interactions create many curved wave fronts and multiple wave packets.

**IMPACT/APPLICATIONS**

This work will help to determine the importance of and the requirements for nonhydrostatic forecast systems for naval applications. The scales and features which will require nonhydrostatic simulation are being assessed.

**RELATED PROJECTS**

The NRL project Autonomous Characterization of Environmentally Induced Non-Acoustic Noise and the Adaptation of Multi-Sensor USW Networks. (6.2, Undersea Warfare) is related to this project because it involves nonhydrostatic modeling of the SW06 experimental area and time and comparison with measurements taken during SW06. Components of SW06 are funded through this ONR NLIWI DRI.
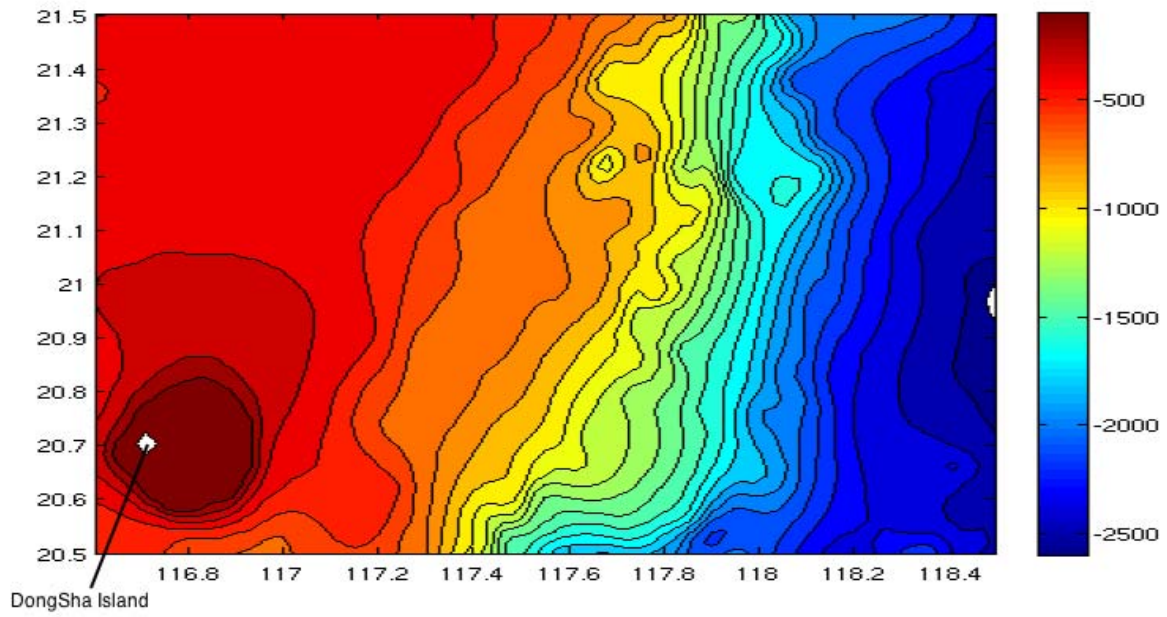
***Figure 1. Bathymetry of model domain around DongSha Island from DBDB2 augmented by Ko using data from Taiwanese scientists.***
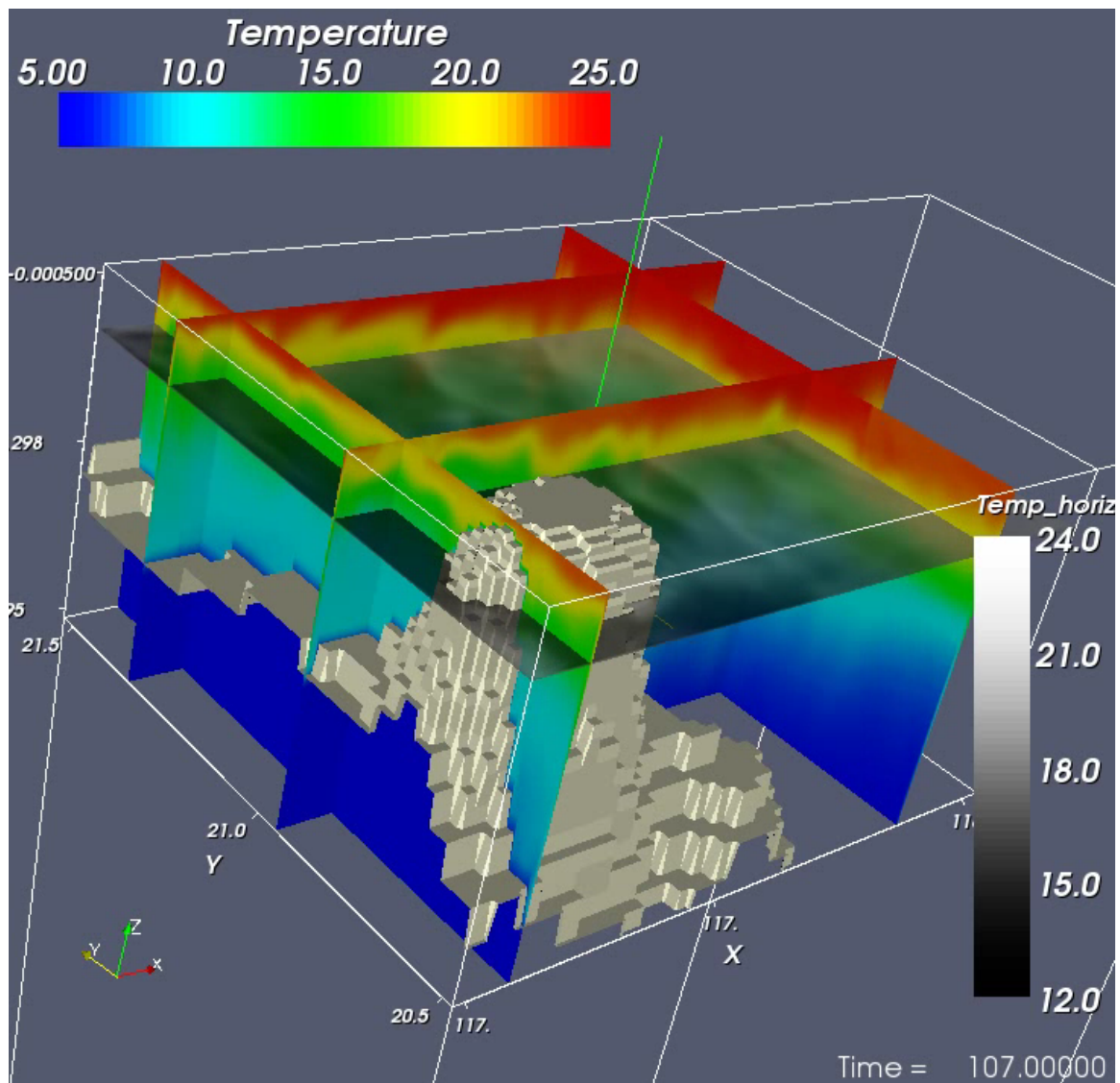
*Figure 2. Vertical and horizontal slices of temperature from the NRL-MIT hindcast of the SCS after 4 days and 11 hours of simulation. This is the Donsha Plateau (Dongsha Island is the land mass in the southwest corner of the domain). The vertical slice is at 100m. NLIWs are clearly visible as they move westwardly up the slope and across the plateau. There is significant curvature in the waves in response to the topography. Large amplitude NLIWs of depression can be seen in the vertical slices, particularly in the northeast area. The thermocline becomes much shallower on the western side of the plateau and the internal wave activity is smaller.*